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*Effect of one*

# Low Thinning

*on cove and slope hardwoods in the New Jersey highlands*

*by H. B. Tepper and G. T. Bamford*

## About the authors . . .

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THE exact value of thinning in managing hardwoods is not yet known. Further study of the many factors that affect thinning results is needed. These factors include methods and intensities of thinning, ages at which thinnings are started or repeated, effects of species composition in mixed stands, and influence of site index on response to thinning.

In view of the increasing interest in managing hardwoods, the results of a small study of hardwood thinning in the New Jersey highlands should be helpful. The study was begun in 1928 by the New Jersey Department of Conservation and Development. The results during the first 27 years are reported here.[1]

[1] The 10-year results of a portion of this study have already been reported: Moore, E. B., and Waldron, A. F. Growth of thinned and unthinned hardwoods on a cove site in the New Jersey highlands. N. J. Dept. Conserv. and Devlpmt., Div. Forests and Parks Tech. Note 8. 4 pp. 1939.

# *THE STUDY AREA*

The thinning study was made in an 18-year-old hardwood stand near Mount Arlington, Morris County, New Jersey. The stand, which had developed after a clear-cutting for cordwood and mine props, was even-aged and consisted of two forest types correlated with slope and cove topography. On the slope was oak-hickory, composed mainly of red oaks (black and northern red) and hickory, with some white ash, red maple, and white and chestnut oaks. American hophornbeam, flowering dogwood, and sugar maple were present in smaller numbers. In the cove, the stand was mixed hardwoods, chiefly white ash, yellow-poplar, and red maple, with some red and white oaks. American elm, hickory, flowering dogwood, aspen, and American hophornbeam occurred in small numbers.

Four $\frac{1}{4}$-acre plots were established, two on the southeast-facing slope at an elevation of 1,100 feet, two in the cove at an elevation of 1,000 feet. In 1955, at a stand age of 45 years, average height of dominant and codominant trees was 53 feet on the slope plots, and 63 feet on the cove plots. These heights correspond to site indices of 60 and 70 respectively.[2]

# *THE THINNING*

In 1928, one slope plot and one cove plot were given a moderate-to-heavy low thinning. Many of the suppressed and intermediate trees were removed along with a few poorly formed dominants and codominants. In the slope plot the thinning took out 64 percent of the stems and 49 percent of the basal area. Red oaks and hickory were favored; after thinning, these species made up 93 percent of the stems and 95 percent of the basal area. In the cove plot, 61 percent of the stems and 44 percent of the basal area were removed. White ash, yellow-poplar, white oaks, and red oaks were favored, while many of the red maples and trees of miscellaneous species were cut. After thinning, white ash, yellow-poplar, and the red oaks made up 83 percent of the stems and 80 percent of the basal area.

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[2]Schnur, G. L. Yield, stand, and volume tables for even-aged upland oak forests. U. S. Dept. Agr. Tech. Bul. 560. 88 pp. 1937.

Two years later, E. B. Moore examined these plots and judged that the thinnings had been too heavy: crowns were slow in closing, and sprouts from cut stumps were already 4 to 5 feet tall. In 1938, after 10 years, the canopy still was not closed.[1]

Present observations indicate that the heavy thinning had no markedly harmful effect on the residual stand. None of the sprouts have become dominant, and the thinned trees do not have larger branch stubs nor less clear length of bole than those on the unthinned plots.

## 27-YEAR CHANGES

Trees on the four plots have been remeasured periodically, the last time in 1955 when the stand was 45 years old. Changes over the 27-year period for each of the two sites are discussed below.

### *Slope Plots*

Growth in diameter, volume, and basal area has been rather slow on the unthinned slope plot (tables 1 and 2). The trees present in 1955 have averaged only 0.122 inch in annual diameter increment over the life of the stand. However, dominants and codominants have averaged 0.167 inch per year. The peak in periodic annual growth of merchantable cubic-foot volume, 72 cubic feet, occurred when the stand was between 33 and 40 years old. This stand reached its largest recorded basal area at 40 years. Since then the annual growth rate has declined, in both cubic volume and basal area.

Red oaks, white ash, and red maple increased their proportions of total stems in the unthinned stand during the 27 years. However, only the red oaks increased proportionally in basal area. At the time of the last tally, they contributed almost all of the merchantable cubic-foot volume and 85 percent of the basal area.

On the other hand, hickories, the second most abundant species at the beginning of the study, decreased in percent of stems and basal area. Their slow growth and relatively high mortality are apparently due to suppression by other species, especially red oaks.

Before treatment, the thinned plot was similar to the

control plot, except that it had somewhat fewer and larger stems and slightly different composition (table 2). Since most of the small stems were removed, relatively few trees died. After 27 years, the thinned stand had only 64, or 16 percent, fewer stems per acre than in 1928. In contrast, approximately 65 percent of the original stems in the control plot had died by 1955.

Although the merchantable cubic-foot volumes of the two plots were almost equal in 1955, that of the thinned plot was distributed on fewer--and therefore larger--trees. In 1955, at 45 years of age, the control plot had 196 dominant red oaks per acre averaging 7.5 inches in diameter, while the thinned plot had 152 with an average diameter of 8.4 inches. Four of the red oaks on the thinned plot were 11 inches or larger; none of this size occurred on the control.

*Cove Plots*

Both height and diameter growth on the unthinned cove plot have been considerably better than on the unthinned slope plot. Stems present on the cove plot in 1955 had grown an annual average of 0.131 inch in diameter during their life; dominants and codominants average 0.182 inch. The peak in periodic annual growth of merchantable cubic-foot volume--146 cubic feet--occurred when the stand was between 28 and 33 years of age. Maximum basal area was attained in 1943 when the stand was 33 years old (table 1). The period of peak volume increment and time when maximum basal area was reached came approximately 5 years earlier than in the slope stand.

Table 1.--Changes in the undisturbed cove and slope plots over 27 years

| Stand age (years) | Stems per acre | | Basal area per acre | | Average diameter (b.h.) | | Merchantable volume per acre | |
|---|---|---|---|---|---|---|---|---|
| | Cove | Slope | Cove | Slope | Cove | Slope | Cove | Slope |
| | Number | | Square feet | | Inches | | Cubic feet | |
| 18 | 1,600 | 1,372 | 66 | 50 | 2.7 | 2.6 | 152 | 52 |
| 23 | 1,344 | 1,172 | 81 | 60 | 3.3 | 3.0 | 476 | 176 |
| 28 | 1,244 | 980 | 100 | 67 | 3.8 | 3.5 | 952 | 412 |
| 33 | 980 | 816 | 109 | 73 | 4.5 | 4.0 | 1,684 | 732 |
| 40 | 672 | 620 | 100 | 81 | 5.2 | 4.9 | 2,028 | 1,236 |
| 45 | 488 | 476 | 96 | 79 | 5.9 | 5.5 | 2,240 | 1,448 |

Table 2.--Composition and volume changes in thinned and unthinned stands on the slope plots[1]

| Stand and species | Stems per acre at-- | | | | Basal area per acre at-- | | | | Average d.b.h. at-- | | | | Merchantable volume per acre at-- | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 18 years | | 33 years | 45 years | 18 years | | 33 years | 45 years | 18 years | | 33 years | 45 years | 18 years | | 33 years | 45 years |
| | BT[2] | AT[2] | | | BT | AT | | | BT | AT | | | BT | AT | | |
| | Number | | | | Square feet | | | | Inches | | | | Cubic feet | | | |
| UNTHINNED STAND: | | | | | | | | | | | | | | | | |
| White oaks | 32 | -- | 32 | 4 | 1 | -- | 2 | 1 | 2.6 | -- | 3.3 | 6.0 | -- | -- | 12 | 16 |
| Red oaks | 692 | -- | 416 | 248 | 32 | -- | 56 | 67 | 2.9 | -- | 5.0 | 7.0 | 52 | -- | 684 | 1,380 |
| White ash | 124 | -- | 108 | 72 | 3 | -- | 3 | 2 | 2.1 | -- | 2.2 | 2.3 | -- | -- | -- | -- |
| Red maple | 84 | -- | 76 | 72 | 3 | -- | 4 | 4 | 2.4 | -- | 3.2 | 3.0 | -- | -- | 16 | 32 |
| Hickory | 372 | -- | 160 | 80 | 9 | -- | 7 | 5 | 2.1 | -- | 2.8 | 3.4 | -- | -- | 20 | 20 |
| Others[3] | 68 | -- | 24 | -- | 2 | -- | 1 | -- | 2.3 | -- | 2.5 | -- | -- | -- | -- | -- |
| All species | 1,372 | -- | 816 | 476 | 50 | -- | 73 | 79 | 2.6 | -- | 4.0 | 5.5 | 52 | -- | 732 | 1,448 |
| THINNED STAND: | | | | | | | | | | | | | | | | |
| White oaks | 40 | 8 | 8 | 4 | 2 | 1 | 2 | 1 | 2.8 | 4.1 | 6.1 | 5.0 | 8 | 8 | 28 | 8 |
| Red oaks | 488 | 220 | 212 | 164 | 27 | 17 | 45 | 60 | 3.2 | 3.8 | 6.3 | 8.2 | 52 | 52 | 732 | 1,356 |
| White ash | 56 | 16 | 20 | 24 | 2 | -- | 1 | 1 | 2.2 | 2.3 | 2.5 | 2.6 | -- | -- | -- | -- |
| Red maple | 40 | 4 | 8 | 32 | 1 | -- | 1 | 1 | 2.5 | 2.0 | 3.8 | 2.7 | -- | -- | 8 | 8 |
| Hickory | 376 | 140 | 136 | 100 | 9 | 4 | 7 | 9 | 2.1 | 2.3 | 3.2 | 4.0 | -- | -- | 8 | 52 |
| Others[3] | 68 | -- | 8 | -- | 2 | -- | 1 | -- | 2.4 | -- | 3.8 | -- | -- | -- | 8 | -- |
| All species | 1,068 | 388 | 392 | 324 | 43 | 22 | 57 | 72 | 2.7 | 3.3 | 5.1 | 6.4 | 60 | 60 | 784 | 1,424 |

[1] Limited to stems 1.6 inches d.b.h. and larger. Volumes are to a 4-inch top d.o.b.

[2] BT - before thinning; AT - after thinning.

[3] Included are American hophornbeam, flowering dogwood, and sugar maple.

Table 3.--Composition and volume changes in thinned and unthinned stands on a cove site[1]

| Stand and species | Stems per acre at-- | | | | Basal area per acre at-- | | | | Average d.b.h. at-- | | | | Merchantable volume per acre at-- | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 18 years | | 33 years | 45 years | 18 years | | 33 years | 45 years | 18 years | | 33 years | 45 years | 18 years | | 33 years | 45 years |
| | BT[2] | AT[2] | | | BT | AT | | | BT | AT | | | BT | AT | | |
| | Number | | | | Square feet | | | | Inches | | | | Cubic feet | | | |
| UNTHINNED STAND: | | | | | | | | | | | | | | | | |
| White oak | 28 | -- | 8 | -- | 1 | -- | 1 | -- | 2.7 | -- | 3.5 | -- | -- | -- | 4 | -- |
| Red oaks | 96 | -- | 36 | 24 | 5 | -- | 4 | 5 | 3.0 | -- | 4.8 | 6.1 | -- | -- | 56 | 96 |
| Yellow-poplar | 412 | -- | 196 | 60 | 21 | -- | 39 | 26 | 3.0 | -- | 6.0 | 8.9 | 56 | -- | 788 | 696 |
| White ash | 524 | -- | 372 | 172 | 15 | -- | 32 | 39 | 2.3 | -- | 4.0 | 6.4 | -- | -- | 380 | 932 |
| Red maple | 404 | -- | 300 | 208 | 14 | -- | 24 | 24 | 2.5 | -- | 3.9 | 4.6 | 12 | -- | 276 | 472 |
| Others[3] | 136 | -- | 68 | 24 | 10 | -- | 9 | 2 | 3.7 | -- | 4.9 | 4.4 | 84 | -- | 180 | 44 |
| All species | 1,600 | -- | 980 | 488 | 66 | -- | 109 | 96 | 2.7 | -- | 4.5 | 5.9 | 152 | -- | 1,684 | 2,240 |
| THINNED STAND: | | | | | | | | | | | | | | | | |
| White oak | 24 | 20 | 20 | -- | 1 | 1 | 3 | -- | 3.3 | 3.5 | 5.6 | -- | 8 | 8 | 68 | -- |
| Red oaks | 176 | 72 | 68 | 40 | 11 | 6 | 13 | 11 | 3.3 | 4.0 | 5.9 | 7.0 | 24 | 24 | 236 | 256 |
| Yellow-poplar | 200 | 116 | 104 | 80 | 17 | 14 | 41 | 50 | 3.9 | 4.6 | 8.5 | 10.7 | 120 | 112 | 992 | 1,420 |
| White ash | 400 | 176 | 168 | 116 | 14 | 8 | 19 | 23 | 2.5 | 2.9 | 4.5 | 6.0 | -- | -- | 256 | 480 |
| Red maple | 152 | 28 | 32 | 24 | 7 | 2 | 5 | 5 | 2.9 | 3.5 | 5.2 | 6.1 | 8 | -- | 88 | 104 |
| Others[3] | 176 | 24 | 28 | 12 | 13 | 4 | 9 | 4 | 3.7 | 5.7 | 7.7 | 8.0 | 100 | 68 | 228 | 112 |
| All species | 1,128 | 436 | 420 | 272 | 63 | 35 | 90 | 93 | 3.2 | 3.8 | 6.3 | 7.9 | 260 | 212 | 1,868 | 2,372 |

[1]Limited to stems 1.6 inches d.b.h. and larger. Volumes are to a 4-inch top d.o.b.

[2]BT - before thinning; AT - after thinning.

[3]Included are American elm, hickory, flowering dogwood, aspen, and American hophornbeam.

In the unthinned cove plot, several interesting changes in species composition have occurred during the 27 years (table 3). White ash and red maple have increased in proportions of both stems and basal area; whereas yellow-poplar has decreased in these respects, and also in its proportion of merchantable volume. Nevertheless, yellow-poplar is still a major stand component, contributing 31 percent of the merchantable volume. White oaks declined in representation here as they did on the slope site. Red oaks, on the other hand, have maintained themselves, though they are but a minor component on the cove plot. Hickory is even more poorly represented, the last tally showing only 1 stem over 2 inches in diameter.

The thinned plot differed somewhat from the unthinned stand: even before thinning, it had fewer and larger stems; it also had proportionally less red maple and yellow-poplar, but more red oaks, white ash, and miscellaneous species. While thinning increased the proportions of red oaks, yellow-poplar, and white ash stems, only the last two species were able to maintain this advantage during the succeeding 27 years.

Yellow-poplar, however, showed a markedly stronger growth response to thinning than white ash. In fact, this response and the resultant trend among yellow-poplars toward dominance in the stand was one of the most significant effects of the thinning. In terms of basal area, volume, and crop trees, yellow-poplar in 1955 formed much higher proportions in the thinned plot than in the unthinned stand. It made up 54 percent of the basal area and 60 percent of the cubic-foot volume on the thinned plot--about twice as much as on the unthinned control plot (table 4). Among 25 selected crop trees on each plot (100 per acre), twice as

Table 4.--Comparative distribution of yellow-poplar and white ash on the thinned and unthinned cove plots, 1955

| Species | Plot | Number of stems | Basal area | Merchantable cubic-foot volume |
|---|---|---|---|---|
| | | Percent of total | Percent of total | Percent of total |
| Yellow-poplar | Thinned | 29 | 54 | 60 |
| | Unthinned | 12 | 27 | 31 |
| White ash | Thinned | 43 | 25 | 20 |
| | Unthinned | 35 | 41 | 42 |

Table 5.--Changes in the number and diameter distribution of the 25 largest white ash and yellow-poplars per plot in the cove stand

| Plot | Species | Stems per plot at-- | | Diameter distribution per plot at-- | |
|---|---|---|---|---|---|
| | | 18 years | 45 years | 18 years | 45 years |
| | | Number | | Inches | |
| Thinned | White ash | 5 | 9 | 4-5 | 6- 9 |
| | Yellow-poplar | 20 | 16 | 4-7 | 9-16 |
| Unthinned | White ash | 4 | 17 | 4 only | 7-12 |
| | Yellow-poplar | 21 | 8 | 4-6 | 8-12 |

many yellow-poplars qualified on the thinned plot as on the control (table 5).

The gains--made largely at the expense of white ash--resulted primarily from faster growth by the yellow-poplars, not from differential mortality, for in 1955 there still were more ash stems than yellow-poplar stems on both plots (table 4). The stronger growth of yellow-poplar in the thinned stand, as compared to ash, is also indicated by the proportions of total stems of each species in dominant and codominant crown positions, as shown below:

| *Stand* | *White ash (percent)* | *Yellow-poplar (percent)* |
|---|---|---|
| Thinned | 33 | 80 |
| Unthinned | 51 | 67 |

Thinning reduced mortality: 38 percent of the stems on the thinned plot died during the 27 years as compared to 70 percent on the control plot. Almost all of the deaths in the thinned plot occurred during the last 12 years of the study.

Thinning also resulted in an increase in average tree diameter: immediately after thinning it was 1.1 inch greater than in the unthinned plot; 27 years later it was 2.0 inches greater. A differential of 0.9 inches in diameter growth in 27 years, while of importance, is not spectacular. However, it may appreciably reduce the time necessary to produce a marketable crop of sawtimber.

Merchantable volumes at 45 years did not differ greatly between the two cove plots, but thinning did cause a

more desirable distribution of this volume. In the control plot, desirable species formed 77 percent of the total merchantable volume: yellow-poplar, 31 percent; white ash, 42 percent; and red oaks, 4 percent. In the thinned plot, desirable species made up 91 percent of the total volume: yellow-poplar, 60 percent; white ash, 20 percent; and red oaks, 11 percent.

Although a quality measure was not included in the tally, stems in the thinned plot are not only larger in diameter, but contain less crook and other deformities than those on the unthinned plot.

# *DISCUSSION*

Since this study was relatively small, limited to one locality and without replication of plots, conclusions drawn from the data must be considered tentative. However, for stands and sites similar to those used in the study, the data strongly support these two thinning recommendations.

1. In oak-hickory slope stands, favor the red oaks over hickory. Hickory is both slower growing and less desirable as a wood product. (Minckler *et al.* reached a similar conclusion for oak-hickory stands in Illinois.[3])

2. In cove stands, favor yellow-poplar over white ash. Although both are desirable species, yellow-poplar on these sites shows a much better growth response to thinning.

Just when the initial thinning should be made is a moot question. However, analysis of past growth rates of the unthinned stands provides some clues. In this we need consider only crop trees, or in hardwood stands managed for saw logs, only about 100 trees per acre. The following tabulation shows annual cubic-foot growth[4] for the 100 largest, and thus most likely crop trees per acre on each site:

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[3]Minckler, L. S., Fassnacht, D. A., and Train, R. K. Growth and species evaluation of some unmanaged upland hardwoods in southern Illinois. U. S. Forest Serv. Central States Forest Expt. Sta. Tech. Paper 110. 9 pp. 1948.

[4]Calculated on the basis of the 25 largest white ash and yellow-poplar and 25 largest red oaks on the cove and slope check plots, respectively.

| *Period (years)* | *Cove site* | *Slope site* |
|---|---|---|
| 18-23 | 37 | 25 |
| 24-28 | 62 | 27 |
| 29-33 | 63 | 37 |
| 34-40 | 38 | 39 |
| 41-45 | 32 | 41 |

These figures show that on the slope sites the growth rate was still on the increase up to 45 years, while on the cove site the peak had been reached by 33 years. However, the rate of increase in both stands had declined several years earlier. For best silvicultural results, the stands probably should have been thinned at the onset of the decline in growth rates--perhaps at 28 years on the cove site and 33 years on the slope.

If thinnings were made 10 or 15 years later than in this study, there would still be a sufficient number of desirable trees to select from in choosing crop trees, and the opportunity of realizing a return on the thinning operation would be greater. Also the fewer, more fully developed individuals per acre would make it easier to decide which trees to leave. As the number of stems that would have to be cut in older stands would also be less, thinning costs might be reduced.

This study has shown that an early low thinning has a desirable effect on stand growth. Assuming that these results would be qualitatively reproducible in stands 10 to 15 years older than the 18-year-old stands of this study, the authors recommend that cove stands, but not slope sites, receive this treatment. Changes in stand composition and increases in diameter growth on the slope site seemed too slight to warrant the investment of time and money, whereas in the cove stand thinning resulted in the growth of larger stems of higher quality and in a more desirable volume distribution. These facts, along with the higher prices paid for yellow-poplar stumpage, suggest that such thinnings would be profitable, that the value of the final crop would be markedly increased. Unfortunately, no thinning costs nor final yield data are available on which to base more definite conclusions.

Crown thinnings, although not studied, also might be an acceptable method in cove stands. Since low thinning stimulated growth and resulted in more desirable volume distribution, it seems reasonable to expect that proper application of crown thinnings would result in a similar, or perhaps greater, response.

# *SUMMARY*

In 1928, four ¼-acre plots were established in an 18-year-old stand: two plots on a slope site stocked chiefly with red oaks and hickory; two in a cove where the trees were mainly yellow-poplar, white ash, and red maple. A low thinning was applied to one plot of each pair, removing 61 to 64 percent of the stems and 44 to 49 percent of the basal area.

Over a 27-year period the chief effects of thinning on the slope stand were to reduce mortality and to concentrate growth on fewer, slightly larger trees than in the unthinned stand. However, these effects were so slight that similar thinning of slope stands is not recommended.

Effects on cove sites were much greater, largely because the thinning caused yellow-poplar to form a higher proportion of the stand. Although cubic-foot volume at 45 years was not appreciably different, this volume in the thinned stand was then on somewhat larger and better quality stems, and in more desirable species. While both plots had about the same number of yellow-poplar crop trees at 18 years, at 45 years the thinned plot had twice as many.

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